

Design and Implementation of an Obstacle Detection and Emergency Brake for Autonomous Car

Nkurunziza Kenneth^{1*}, Aglaia Mantzana², Wirote Ritthong³, Omar Muhammed Neda⁴

¹Department of Automotive and Power Engineering, University Private African Franco-Arabe (UPAFA), Bamako, Mali.

²Department of STEM, Robotics and Sustainability Education, Hellenic Open University, Patras, Western Greece, Greece.

³Faculty of Engineering and Technology, Shinawatra University, Bang Toei, Pathum Thani, Thailand.

⁴Department of Electrical Power Engineering, Sunni Diwan Endowment, Baghdad, Baghdad Governorate, Iraq.
nkurunzizakenneth1@gmail.com¹, info@eap.gr², wirote.r@siu.ac.th³, omar.muhammed@imamaladham.edu.iq⁴

*Corresponding author

Abstract: In general, the system of an autonomous robotic car integrates a range of sensors (ultrasonic, infrared, and LIDAR) to detect obstacles, a microcontroller to process sensor data, and sensors for precise movement control. The primary aim was to develop an efficient, reliable solution for real-time navigation and obstacle avoidance, enhancing the autonomous capabilities of robotic vehicles. The design incorporates advanced control strategies, including real-time data processing algorithms and predictive control models, to ensure smooth and responsive navigation. The system was rigorously tested using both qualitative and quantitative techniques. Data were collected and analyzed through a series of controlled experiments, and the performance was evaluated using statistical methods and thematic analysis. The developed system demonstrated high efficiency and reliability, achieving a 100% success rate in obstacle detection and avoidance during testing. The results showed a significant improvement over existing systems, which typically achieve around efficiency. This efficiency was validated through simulation software and real-world testing. Overall, the paper advances autonomous robotic technology by providing a robust framework for obstacle detection and avoidance. The implementation of this system enhances the safety and operational efficiency of autonomous robotic cars, making them more viable for practical applications in various environments.

Keywords: Light Detection and Ranging; Brake Controller; Electronic Control Unit; Electrical Control Switch; Wire Connector; Automated Guided Vehicles; Autonomous Vehicles; Integrated Circuits.

Cite as: N. Kenneth, A. Mantzana, W. Ritthong, and O. M. Neda, "Design and Implementation of an Obstacle Detection and Emergency Brake for Autonomous Car," *AVE Trends in Intelligent Energy Letters*, vol. 2, no. 1, pp. 24–36, 2026.

Journal Homepage: <https://www.avepubs.com/user/journals/details/ATIEL>

Received on: 18/04/2025, **Revised on:** 09/07/2025, **Accepted on:** 16/09/2025, **Published on:** 07/06/2026

DOI: <https://doi.org/10.64091/ATIEL.2026.000323>

1. Introduction

Robotics is a multidisciplinary field that combines mechanical engineering, electrical engineering, electronics, computer science, control and artificial intelligence to design, build, operate and control machines capable of performing tasks with limited or no human intervention. Modern robotic systems are increasingly designed to sense their environment, make decisions and respond to changing environmental conditions [2]. These capabilities have broadened the application of robotics from traditional industrial manufacturing to healthcare, agriculture, transportation, logistics, security, education, military operations and domestic environments. One important development in this field is autonomous robotic vehicles, which can navigate and move without continuous human control [1]. The transportation environments are dynamic and unpredictable, so the development of autonomous robotic cars is especially important. A robotic car must sense the environment at all times, detect

Copyright © 2026 N. Kenneth *et al.*, licensed to AVE Trends Publishing Company. This is an open access article distributed under [CC BY-NC-SA 4.0](https://creativecommons.org/licenses/by-nc-sa/4.0/), which permits copying, remixing, redistributing, transformation, and building upon the material in any medium so long as the original work is properly cited.

obstacles, plan a safe trajectory and control the motion accordingly. Autonomous vehicles, unlike manually controlled vehicles, need to make decisions based on sensor data and implement them through electronic control systems.

The effectiveness of such a system therefore depends on the accuracy of the environmental sensing, the speed of data processing, the reliability of the control algorithm, and the vehicle's ability to respond to obstacles in a timely fashion [3]. The concept of autonomous machines has been around for many years. Still, the major development of autonomous robotics came with the invention of microcontrollers, embedded systems, sensors, wireless communication, artificial intelligence and real-time processing technologies. Historically, robotic systems have been limited to pre-programmed motion and controlled environments. Today's autonomous robots, however, can use sensor information to modify their behavior to the conditions around them [5]. This development has made autonomous robotic vehicles increasingly suitable for applications where human operation can be difficult, dangerous, inefficient, or expensive. Road safety is a key driver for the development of autonomous navigation technologies. According to data from the Rwanda National Police (RNP) on IGIHE.COM, more than 3,000 traffic accidents were recorded in Rwanda from January to June 2023. The main contributing factors identified were driver distraction, failure to maintain a safe distance from the preceding vehicle, and excessive speed, accounting for about 31%, 15%, and 13% of the reported incidents, respectively. Figures 1 and 2 show the importance of developing technologies to create safer transportation systems.

While autonomous robotic cars alone cannot eliminate all road accidents, intelligent mechanisms for obstacle detection and avoidance can help reduce collisions caused by delayed human responses or a lack of awareness of the surrounding environment [7]. To understand the immediate environment, an autonomous robotic car requires a reliable perception system. Sensors provide the main interface between the physical environment and the electronic control system. The current study combines ultrasonic, infrared and Light Detection and Ranging (LiDAR) sensors to detect obstacles at varying distances and under varying environmental conditions. A variety of sensing technologies can be used to get a perception capability more complete than that from a single sensor. Each sensing technology has its advantages and limitations, and fusing their outputs can improve the reliability of obstacle detection and navigation [5]. Ultrasonic sensors work by sending high-frequency sound waves and measuring the time it takes for the reflected signal to return to the sensor. The measured time interval can then be used to estimate the distance to an obstacle from the robotic car [17]. Ultrasonic sensors are cheap, easy to implement and work well for short-range obstacle detection. They can be especially useful for finding objects directly in front of the vehicle. However, their performance can be affected by shape, material, orientation and surface characteristics of an obstacle. Hence, integration with other sensing technologies can be beneficial for ultrasonic sensing [6]. Infrared sensors are another mechanism for detection of nearby objects.

Typically, these sensors emit infrared radiation and detect the amount of reflected infrared radiation from surrounding objects. Infrared sensing works well for short-range applications and can provide quick responses [9]. Robotic cars can use infrared sensors to detect obstacles and aid navigation decisions when approaching an object. However, the infrared performance may be affected by lighting conditions, surface reflectivity, and environmental interference. Therefore, combining infrared information with ultrasonic and LiDAR measurements may improve the robustness of the entire sensing system [12]. LiDAR (Light Detection and Ranging) is a more advanced method of environmental perception that measures distance with laser pulses. The system determines the distance to objects around it by measuring the time it takes for the light it emits to travel to an object and back to the sensor. Depending on the sensor setup, LiDAR can provide accurate distance measurements and generate detailed representations of the environment. This capability makes LiDAR especially valuable for autonomous navigation, mapping, and obstacle avoidance. However, LiDAR systems can be more expensive and computationally intensive than basic ultrasonic or infrared sensors. Thus, combining LiDAR with cheaper sensors provides an opportunity to balance sensing accuracy, system complexity and implementation cost [13]. The main sensing element of the proposed autonomous robotic car is the integration of ultrasonic, infrared, and LiDAR sensors [16].

The sensor data is sent to a microcontroller or electronic control unit. The microcontroller, or electronic control unit, processes the data to determine whether an obstruction is present and whether corrective action is required. As the robotic car moves, the control system continuously evaluates sensor readings [10]. If an obstacle is detected within a given safety distance, the controller can take appropriate actions, such as slowing the vehicle, engaging the braking mechanism, changing direction or stopping the vehicle completely. Interaction between sensing and control at run-time is essential for autonomous operation. The electronic control unit plays an important role in co-ordinating the various components of the robotic car. It takes in sensor readings, analyses the data, executes the programmed decision logic, and sends control signals to the motors and brakes. Electrical control switches, wire connectors, motor drivers and associated electronic components provide physical connections for communication between the sensors, controller and actuators. Reliability is essential for these components because any failure in communication or power delivery can impact the vehicle's ability to detect and respond to obstacles [15]. Moreover, the proposed system combines real-time data-processing algorithms for fast decision-making. For autonomous navigation, the system must process sensor information quickly because the distance to an obstacle can change rapidly as the vehicle moves.

Delayed processing may lead to an insufficient braking distance or an incorrect steering decision. Thus, the control algorithm needs to be computationally efficient and make good decisions [12].

Predictive control strategies can further improve system performance by considering the vehicle's current position, speed, direction and detected obstacles to determine an appropriate movement response. Obstacle avoidance is more than simply sensing an object. The system must also decide what a reasonable response would be. For example, if the controller detects an obstacle directly in front of the vehicle, it may first decelerate and look for an alternate route [14]. If there is enough room, the vehicle can turn and continue. If a safe path is not available, the braking system can be used to bring the vehicle to a controlled stop. This decision-making process is a good example of the importance of combining sensing, processing and actuation into a cohesive autonomous-control framework. The performance of an autonomous robotic car depends on several measurable factors. These include the accuracy of obstacle detection, response time, avoidance success rate, braking effectiveness, navigation stability and overall system reliability. The developed system is evaluated in this study through controlled experimental testing, simulation and real-world scenarios [6]. Different obstacle positions, distances, movement conditions and environmental situations can be considered to see whether the system responds consistently to detected obstacles. Objective evidence of system performance comes from quantitative measurements, while practical issues related to movement behaviour, sensor performance and navigation stability are highlighted through qualitative observations [8].

The use of simulation software also provides a way of evaluating the proposed system before or alongside physical testing. Under controlled conditions, simulation allows the reproduction of various obstacle arrangements and movement scenarios. It can also be used to locate weaknesses in the control algorithm and to reduce the need for repeated physical experiments in the early stages of development. However, testing is still needed in practice because the physical environment contains factors that may not be fully represented in simulation, such as sensor noise, surface irregularities, lighting variations, mechanical vibration and unexpected obstacles [4]. Compared with systems based on a single sensing mechanism, the proposed system is expected to be more reliable due to its multiple sensors. Sensor fusion can provide complementary information and mitigate the limitations of individual sensors. Ultrasonic sensors are useful for short-range distance measurements, infrared sensors provide fast proximity detection, and LiDAR provides more detailed distance information. By processing these inputs together, the controller can make better navigation decisions [9]. Thus, the development of this autonomous robotic car helps the overall development of intelligent transportation and autonomous robotic systems [11].

The proposed approach integrates relatively accessible sensing and embedded-control technologies to develop a system capable of perceiving the environment and avoiding obstacles in real time. Potential applications include controlled transportation environments, warehouses, industrial facilities, educational robotics, agricultural environments, security applications and other areas where autonomous movement is needed. The ultimate goal of the proposed autonomous robotic car is to provide an efficient, responsive and reliable platform for obstacle detection and avoidance. The vehicle is equipped with ultrasonic, infrared and LiDAR sensors, integrated with an electronic control system based on a microcontroller, enabling it to perceive and react to obstacles while in motion. The use of real-time processing and predictive control strategies also helps achieve smooth, responsive navigation [3]. The system can be evaluated in terms of accuracy, reliability, response time and avoidance performance systematically through simulation, controlled experiments and real-world testing. The development of such a system is particularly relevant when considering improving transportation safety and reducing the risks associated with delayed human responses. The proposed robotic car extends the state of the art in autonomous sensing, control, and navigation and lays a foundation for future work on intelligent, safer autonomous vehicles [1].

1.1. Objective

To design and implement an obstacle detection and emergency brake for an autonomous car. It can navigate obstacles ahead, reduce speed, maintain a safe distance, and, if possible, bypass them or halt if there is no space to continue along its path.

1.2. Justification of Study

In recent years, Autonomous robotic cars can react to obstacles and make accurate decisions at speeds and with precision comparable to or exceeding those of people in similar circumstances, thanks to advanced sensor technology and improved algorithms. When integrated and selected appropriately, sensors can provide sufficient information for autonomous robotic automobiles to navigate without colliding with objects. In the meantime, by implementing efficient algorithms for real-time data interpretation, the robot can process sensor data rapidly and accurately.

1.3. Scope of Study

The paper aims to design and implement an autonomous robotic car capable of detecting and avoiding obstacles. The automotive system integrates advanced sensor technologies, a robust control system, and sensors and radar to enhance the

vehicle's obstacle avoidance capabilities. The goal is to create a system that ensures safe, efficient, and reliable navigation in various environments. The paper includes designing an advanced obstacle detection system, integrating sensors and radar to improve brake responsiveness, and developing algorithms for real-time processing of sensor data. The car will be assembled with necessary components and tested for performance in various driving conditions. The system will offer customizable settings, safety features, real-time driver feedback, and sensor integration. However, automotive systems may have limitations, such as a lack of primary braking, limited flexibility, complex user interfaces, and potential issues with monitoring accuracy.

1.4. State of the Art

The goal is to create a system that ensures efficient, reliable, and safe navigation in various environments. The paper will include designing an advanced obstacle detection system, integrating sensors and radar to improve brake responsiveness, and developing algorithms for real-time processing of sensor data. The paper will also involve constructing the car, testing and validating the system, and integrating the sensors and radar for precise braking. The expected outcomes include improved braking responsiveness, driver comfort and safety, efficient obstacle avoidance, and comprehensive system integration. Future work will focus on integrating the system with primary braking systems, enhancing flexibility, simplifying the user interface, and improving monitoring accuracy. By clearly defining the paper's scope, a systematic approach can be adopted, ultimately enhancing vehicle safety and driver comfort.

2. Methodology

2.1. Requirement Analysis and Materials

This section describes all the equipment to be used in this paper.

2.1.1. Arduino Uno Platform

The ATmega328P microprocessor powers the Arduino Uno. The Arduino Uno has a 16 MHz quartz crystal, 14 digital I/O pins (input/output), 6 PWM output pins, 6 analogue input pins, a USB port, a power jack, an ICSP header, and a reset button. The Arduino can be powered by a battery, an AC-to-DC converter, or a USB wire connected to a computer. A 9V DC 100-500mA power adapter with a 2.1mm barrel plug and positive tip should be the rating.



Figure 1: Arduino, USB cable and power adapter

There is a three-pin jumper next to the USB port. You are powering using a USB cable if the jumper is on two pins close to the USB jack; alternatively, you can power using a battery or wall adapter if automotive is on two pins close to the DC jack. The USB cable is used to transport data serially between the Arduino and the PC during communication.

2.1.2. HC-SR04 Ultrasonic Sensor

The HC-SR04 is a reasonably priced, user-friendly distance-measuring device with a measurement range of 2 to 400 cm (roughly 1 to 13 feet). The sensor consists of two ultrasound transducers. One is a receiver that detects reflected waves, while the other is a transmitter that emits ultrasonic sound. The ultrasonic sensor essentially functions like SONAR, which submarines use to detect submerged objects.

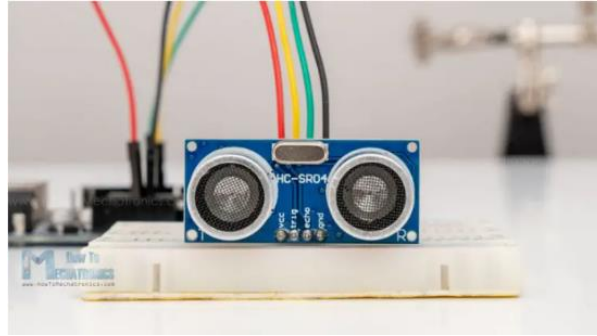


Figure 2: Ultrasonic sensor

Here are its main specifications (Table 1).

Table 1: The main specifications of the ultrasonic sensor

Specification	Value
Operating Voltage	5V DC
Operating Current	15 mA
Operating Frequency	40 kHz
Min Range	2 cm / 1 inch
Max Range	400 cm / 13 feet
Accuracy	3 mm
Measuring Angle	< 15°
Dimension	45 × 20 × 15 mm

Figure 3 below shows the HC-SR04 Ultrasonic Sensor Pinout. Four pins make up the sensor. The Trig and Echo connect to any digital Arduino pin, while VCC and GND connect to the Arduino's 5V and GND pins.

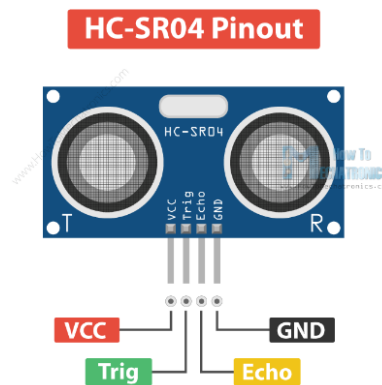


Figure 3: HC-SR04 pinout

The ultrasonic wave is sent from the transmitter using the Trig pin, and the reflected signal is detected using the Echo pin.

2.1.3. The Infrared Sensor

Lane-following systems rely heavily on infrared sensors, especially in automated guided vehicles (AGVs) and autonomous vehicles (AVs). Infrared technology is essential to our everyday existence. TVs use an infrared sensor, for example, to decipher signals from remote controls. Let's examine in more detail the function and importance of infrared sensors. There are many uses for infrared technology in both industry and daily life. For instance, TVs use an infrared sensor to detect signals from remote controls. The primary benefits of infrared sensors are their low power consumption, straightforward construction, and practical properties (Figure 4).

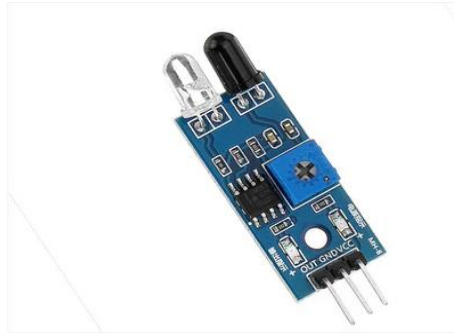


Figure 4: Infrared sensor

The human eye cannot detect infrared radiation. Infrared radiation is present in both the visible and microwave sections of the electromagnetic spectrum (Figure 5).

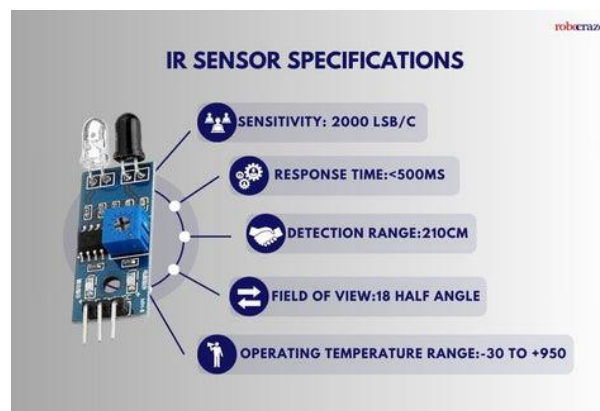


Figure 5: IR sensor specification

2.1.4. L293D Motor-Driver

An integrated circuit automotive chip, a motor driver IC, is typically used to regulate motors in autonomous robots. Robot motors and microprocessors are interfaced with via motor driver integrated circuits (ICs). The L293 series of motor driver integrated circuits, L293D and L293NE, is the most widely utilized range. These integrated circuits are designed to control two DC motors simultaneously. The L293D consists of two H-bridges. The most basic circuit for automotive applications that manages a low-current-rated motor is the H-bridge (Figure 6).

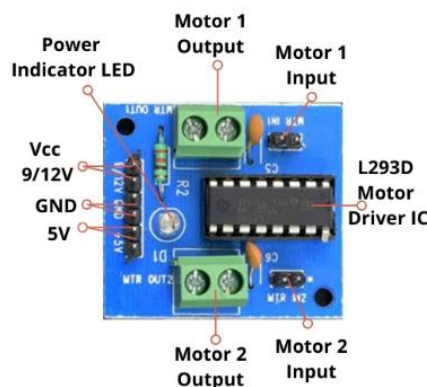


Figure 6: A motor driver

Researchers will use the motor driver IC L293D for this tutorial. The 16 pins on the L293D are made up of the following:

- Ground Pins - 4
- Input Pins - 4
- Output Pins - 4
- Enable Pins - 2
- Voltage Pins – 2

Motor Driver ICs are widely used in autonomous robots. Moreover, motors require larger voltages and currents to run than microprocessors, which typically run at low voltages and with little current. As a result, the CPU is unable to power the motors. The motor driver IC is mostly required for this purpose.

2.1.5. WD Smart Robot Chassis Kit

A robotic platform called the 4WD Smart Robot Chassis Kit is intended to be utilized with an Arduino microcontroller (Figure 7).



Figure 7: 4WD chassis robot kit

A four-wheeled robot chassis, DC motors, wheels, a control board, battery holders, and other parts required to create a working robot are usually included in this kit.

2.1.6. The Block Diagram of an Autonomous Car

The autonomous car block diagram outlines the interconnected systems and processes required for safe, reliable autonomous driving. Sensors, such as cameras, LiDAR, radar, and ultrasonic sensors, form the foundation of the car's perception system (Figure 8).

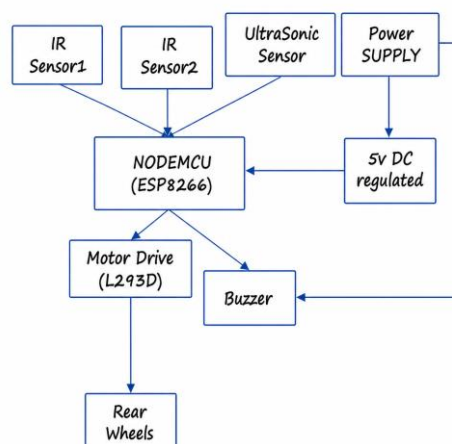


Figure 8: Autonomous car block diagram

The perception module processes sensor data to build a comprehensive understanding of the car's environment, including object detection, environment mapping, and localization. The decision-making module determines appropriate actions for safe driving, including path planning, behavior planning, and risk assessment. The control system executes these decisions, including actuators, drive-by-wire systems, vehicle dynamics, and human-machine interface (HMI). The system also provides interaction points between the car and human occupants, displays and alerts, and manual override. Integration and feedback loops, such as sensor fusion, closed-loop control, and redundant systems, ensure safety and adaptability to real-time changes in the driving environment.

2.1.7. Design of Machine Parts (Software and Design Process)

Software: Computer-Aided Design (CAD) software such as SolidWorks was used to design the car chassis and its top cover to protect the internal automotive circuit wiring, both for 3D printing. Design Process:

- **Frame Design:** The design of a chassis that can accommodate all electronic components securely. Researchers considered factors such as weight distribution and motor placement to optimise balance and manoeuvrability, while not forgetting wheel placement and wheel diameter.
- **Sensor Placement:** Based on designated locations for ultrasonic sensors and infrared sensors, researchers selected the desired obstacle detection range and coverage. Researchers ensured a minimal blind spot and considered potential interference from other components, and positioned them at the front to detect efficiently.

2.1.8. Circuit Automotive Design and Assembly

Based on the following flow chart, researchers were able to formulate a well-designed automotive circuit, as it explains the flow of system components to fulfil its operation (Figure 9).

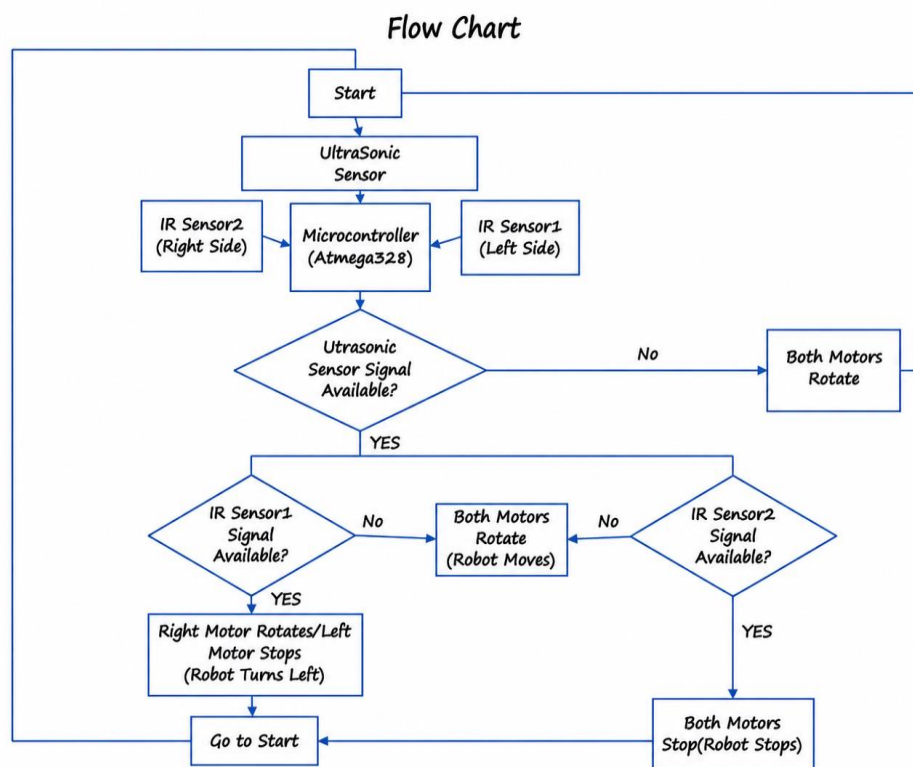


Figure 9: Flow chart

Utilize Fritzing or KiCad software to design the automotive electronic circuit schematic. With the aid of the above circuit, automotive. The automotive circuit will connect all components, including:

- Arduino Uno

- Sensors (ultrasonic sensors)
- Motor drivers
- Motors
- Power supply
- Buzzer

Follow best practices for automotive electronic circuit design, including proper grounding and power management. Once satisfied with the schematic, transfer the design to a breadboard for prototyping and testing individual components before soldering. After successful testing, create a permanent automotive circuit board using a PCB (Printed Circuit Board) manufacturing service or by soldering components onto a pre-made perf board.

3. Result and Discussions

The study design for obstacle detection and emergency braking in an autonomous car is shown in Table 2.

Table 2: Used methodology for the study

Objectives	Hypotheses	Methodology	Statistics
Enhancing Sensor Performance	Improved sensor fusion enhances obstacle detection accuracy.	Experimental Design: Compare the performance of different sensor fusion algorithms in simulated and real-world environments.	Descriptive statistics, performance metrics (detection accuracy, false positives).
Optimizing Path Planning	Adaptive path planning algorithms improve navigation efficiency in urban environments.	Simulation and Testing: Develop and test adaptive path planning algorithms using simulated urban scenarios and real-world data.	Comparative analysis, efficiency metrics (travel time, congestion reduction).
Evaluating Safety Features	Advanced AI-driven decision-making reduces collision risks.	Field Testing: Conduct on-road testing to evaluate the effectiveness of AI algorithms in avoiding obstacles and ensuring passenger safety.	Incident reports, safety metrics (collision rates, emergency braking frequency).
Integration with Urban Infrastructure	Integration with smart city infrastructure enhances AV performance.	Collaborative Study: Partner with urban planners to integrate AVs with smart traffic signals and connected vehicle transports for real-time data exchange.	Integration metrics, efficiency gains (traffic flow improvement).

3.1. Presentation of the Study Area

This presentation discusses the importance of obstacle detection and avoidance systems for autonomous robotic cars, highlighting their potential to enhance safety, advance technology, and improve operational efficiency. The research aims to develop advanced sensor fusion techniques, real-time decision-making algorithms, and user-robot interaction interfaces. The methodology includes LiDAR for 3D mapping, radar for object detection, machine learning algorithms for object recognition, and real-world testing for system reliability.

3.2. Sampling Methods and Techniques

We gathered data from Rwandan technicians, administrators, operators, and maintenance mechanics using written questionnaires. The required information was requested in the questionnaire's questions. We would have been able to record an in-person interview and get the information we required if Kigali Bus Service Ltd. had collected the material through interviews and observation. Data on the different kinds, mobility, longevity, and operation of the research.

3.2.1. Population of the Study

Kigali Bus Service Ltd. has a population of 50, as listed in Table 3.

Table 3: Research population

Technician	Drivers	Operators	Administration	Total
10	20	10	10	50

3.2.2. Sampling Techniques

In Rwanda, we gathered data from technicians, administrators, operators, and drivers using written questionnaires. The required information was requested in the questionnaire's questions (Table 4).

Table 4: Sample of study

Technician	Drivers	Operators	Administration	Total
5	10	5	5	25

We would have been able to record an in-person interview and obtain the information we required if Kigali Bus Service Ltd. had collected it through observation and interviews. 50% of my anticipated sample size was randomly selected to participate in my study

3.2.2.1. Sample Size

Determining the sample size for a study on Obstacle detection and emergency braking for autonomous cars. Solutions are influenced by the study's objectives, required statistical power, and potential limitations such as time and budget constraints. To calculate the necessary sample size, it is essential to define the study's goals, select appropriate statistical parameters, estimate the variability in transport infrastructure production and facility efficiency, and use specialised software or formulas. Practical constraints, such as budget limitations and data-collection feasibility, should also be considered.

3.2.3. Criteria of Participants' Selection

Several factors should be considered when selecting research participants for a transport study. These include home ownership, prior experience with internet usage habits, demographics, technology aptitude, location, and informed consent. Home ownership ensures direct internet access, and prior internet experience facilitates a better understanding of how different user profiles engage with the technology. Demographic traits such as age, gender, income level, and education help evaluate how various groups perceive and use internet solutions. Understanding participants' internet usage habits and technological competence is crucial for assessing how the system impacts different household research scenarios.

3.3. Type of Data and Techniques of Data Collection

Table 5 shows the data type and the data collection techniques.

Table 5: The type of data and techniques of data collection

Activities	Techniques	Instruments
Survey	Questionnaires	Online surveys using Google Forms
	Interviews	Structured interviews
	Focus groups	Group discussions with predefined questions
Observation	Direct observation	Observing participants' interactions with the system
	Video recording	Recording driving sessions to analyze behavior
	Field notes	Written notes on observed behaviors and system usage
Data Analysis	Data mining	Analyzing large datasets to identify patterns and trends
	Statistical analysis	Applying statistical tests to quantify system performance
	Machine learning algorithms	Developing predictive models based on historical data
Interviews with Experts	Expert consultation	Interviewing engineers, designers, or policymakers
	Stakeholder interviews	Engaging with stakeholders to gather insights

3.4. Field Survey

To gauge current awareness, perceptions, and vehicle control, a comprehensive survey plan has been devised. This initiative aims to understand the sentiments and preferences of various stakeholders, including homeowners, businesses, and local communities, towards adopting transport internet harvesting with transport solutions. The survey methodology involves identifying the target population, designing an appropriate sampling strategy, and developing a survey instrument tailored to assess attitudes and readiness for transport technology adoption. The questionnaire will be translated and localized as needed, then pre-tested with a small sample group to refine its effectiveness.

3.5. Data Analysis Techniques

3.5.1. Interviews

The study on obstacle detection and emergency braking for autonomous cars aims to gain comprehensive insights into current adoption rates, perceptions, and challenges within the context of sustainable internet practices in urban environments. Key stakeholders, including homeowners, research providers, technology experts, and environmental policymakers, will be interviewed to understand their perspectives on obstacle detection and emergency braking for autonomous car systems. This purposive sampling approach ensures representation from diverse viewpoints critical to shaping effective transport policies and infrastructure development. The findings from this study will be instrumental in informing strategies to promote internet adoption, optimise internet use, and mitigate environmental impacts in urban settings such as Kigali City. By fostering stakeholder dialogue and leveraging qualitative research methods, the study aims to advance sustainable transport.

3.6. Documentary Review

A thorough review of documentation is crucial for understanding the transport with integrated facilities solutions. This involves defining clear objectives, identifying relevant literature, and selecting papers based on their applicability, reliability, and recency. Structured data gathering and synthesis for Obstacle detection and emergency braking for autonomous cars. are essential to uncover significant patterns, legal frameworks, implementation challenges, and societal impacts related to the internet.

3.7. Data collection Instruments

The Kigali City study on obstacle detection and emergency braking for autonomous cars aims to comprehensively assess awareness, perceptions, and readiness among various stakeholders to adopt these systems. The study plan encompasses a multifaceted approach, including survey questionnaires, interview guides, focus group discussions, observation checklists, telematics devices, sensors, and document reviews. The survey questionnaire will delve into topics such as awareness of internet technologies, attitudes towards sustainability, preferences for internet facilities solutions, and factors influencing adoption decisions.

3.8. Data Analysis Techniques

The study on obstacle detection and emergency braking for autonomous cars in Kigali City employs a range of sophisticated data analysis techniques to evaluate adoption rates, efficacy, and impacts. Thematic analysis is utilized to identify patterns and themes in qualitative data, providing insights into stakeholders' perceptions and challenges related to transport internet systems. Regression analysis examines correlations between variables, such as economic factors and adoption rates, shedding light on the factors influencing the uptake of integrated transport technologies.

3.9. Research Procedure

A detailed process is outlined in the research procedure plan for investigating obstacle detection and emergency braking in an autonomous car. In Kigali City. The significance of coupling brake pedal force and torque in mechanical transmission systems for maximizing efficiency and performance is covered in the Results and Discussion. It analyzes many modeling techniques and their drawbacks, including test-data-based and first-principles approaches. While data-driven models provide exact results but only partially comprehend the system's mechanics, first-principles models provide insights but fall short in this regard. This part also discusses the effects of the model estimation procedure's outcomes. It examines how these findings advance our understanding of dynamic system modeling and mechanical transmission systems, emphasizing their varied applications across disciplines. Overall, this part provides a thorough examination of the conclusions drawn from the model parameter estimates based on experimental data. It recognizes the difficulties and complexities of modeling dynamic systems while emphasizing the crucial role of precise modeling in improving system efficiency and performance. Studies on adaptive automation methods have shown that they can improve system performance in autonomous vehicle control and in human-automation collaboration.

This examined context-aware decision support systems and the dynamic distribution of control authority, emphasizing how effectively they adapt to shifting user preferences and environmental conditions. By using these strategies, autonomous vehicle systems can customize automation levels, decision support, and control authority to correspond with the skills and preferences of human drivers. This fosters productive teamwork and maximizes system resilience. The system offers several advantages, including vehicle speed control, safe operation and internet-based tracking. These features enhance vehicle monitoring, operational safety, and user control. The paper identifies several opportunities, such as improved speed regulation, effective stability control and environmental protection. These benefits can lead to the development of safer, more efficient and

environmentally friendly autonomous vehicles. The paper, however, has some disadvantages. For some automotive workshops, meeting the financial requirements may be challenging. Furthermore, the required materials may not be easily available in the local market. Installation, operation, maintenance and troubleshooting of the system also require skilled personnel.

4. Conclusion and Recommendations

This research paper aims to design and model an autonomous car system capable of detecting obstacles and applying emergency brakes to improve vehicle safety, efficiency and reliability. The system is designed to meet the demand for modern, practical transportation technology that reduces the risk of collisions while operating a vehicle. Self-driving cars have to be able to see what's around them all the time and react fast if something unexpected pops up in front of them. Hence, the implementation of an intelligent obstacle-detection system is important to improve the safety of passengers, vehicles, and other road users around. The proposed system uses a radar sensor to detect obstacles and determine their distance from the vehicle. The system processes the sensor information and automatically activates the emergency braking system when it detects an obstacle within a predefined safety range. This reduces reliance on human reaction time and provides an additional layer of protection against potential collisions. The system also provides timely braking and movement decisions, enabling efficient vehicle control. The paper reflects the evolution of automotive technology toward intelligent and autonomous transportation. It uses a combination of radar sensing and automated braking to provide a practical solution for improved vehicle safety, especially in situations involving sudden obstacles or slow driver response. Overall, the research demonstrates the role of obstacle detection and emergency braking in creating safer, more efficient and more reliable autonomous vehicles and in the wider development of intelligent transport systems.

List of Abbreviations

ADAS	Advanced Driver Assistance Systems
PA	Power Amplifier
SAE	Society of Automotive Engineers
AVs	Autonomous Vehicles
AI	Artificial Intelligence
DC	Direct Current
ICSP	In-Circuit Automotive Serial Programming
AC	Alternating Current
PWM	Pulse Width Modulation
AGVs	Automated Guided Vehicles

Acknowledgement: These researchers would like to thank the University Private African Franco-Arabe (UPAFA), the Hellenic Open University, Shinawatra University, and the Sunni Diwan Endowment for their encouragement, support, and academic aid.

Data Availability Statement: The data underlying the findings of this study can be obtained from the corresponding author upon reasonable request.

Funding Statement: No funding has been obtained to help prepare this manuscript and research work.

Conflicts of Interest Statement: No conflicts of interest have been declared by the authors. Citations and references are mentioned in the information used.

Ethics and Consent Statement: Consent was obtained from the organisation and individual participants during data collection, and ethical approval and participant consent were obtained.

References

1. F. Engels, P. Heidenreich, A. M. Zoubir, F. K. Jondral, and M. Wintermantel, "Advances in Automotive Radar: A framework on computationally efficient high-resolution frequency estimation," *IEEE Signal Processing Magazine*, vol. 34, no. 2, pp. 36–46, 2017.
2. A. Nunes, B. Reimer, and J. F. Coughlin, "People must retain control of autonomous vehicles," *Nature*, vol. 556, no. 4, pp. 169–171, 2018.
3. B. Soualmi, C. Sentouh, J. C. Popieul, and S. Debernard, "Automation-driver cooperative driving in presence of undetected obstacles," *Control Engineering Practice*, vol. 24, no. 3, pp. 106–119, 2014.

4. B. Soualmi, C. Sentouh, J. C. Popieul, and S. Debernard, "A shared control driving assistance system: Interest of using a driver model in both lane keeping and obstacle avoidance situations," *IFAC Proceedings Volumes*, vol. 46, no. 15, pp. 173–178, 2013.
5. A. Benloucif, A. T. Nguyen, C. Sentouh, and J. C. Popieul, "Cooperative trajectory planning for haptic shared control between driver and automation in highway driving," *IEEE Trans. Ind. Electron.*, vol. 66, no. 12, pp. 9846–9857, 2019.
6. X. Chi, Z. Guo, and F. Cheng, "Dynamic obstacle avoidance model of autonomous driving with attention mechanism and temporal residual block," *Alexandria Engineering Journal*, vol. 105, no. 10, pp. 538–548, 2024.
7. D. de Waard, M. van der Hulst, M. Hoedemaeker, and K. A. Brookhuis, "Driver behavior in an emergency situation in the automated highway system," *Transportation Human Factors*, vol. 1, no. 1, pp. 67–82, 1999.
8. Arduino Docs, "UNO R3," *Arduino*, 2026. [Accessed by 05/04/2026].
9. M. R. Endsley, "Toward a theory of situation awareness in dynamic systems," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 37, no. 1, pp. 32–64, 1995.
10. IGIHE, "Recklessness among major causes of road accidents in Rwanda," *IGIHE News*, 2023. [Accessed by 11/02/2025].
11. J. D. Lee and K. A. See, "Trust in automation: Designing for appropriate reliance," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 46, no. 1, pp. 50–80, 2004.
12. J. C. F. de Winter, R. Happee, M. H. Martens, and N. A. Stanton, "Effects of adaptive cruise control and highly automated driving on workload and situation awareness: A review of the empirical evidence," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 27, no. 11, pp. 196–217, 2014.
13. M. Kyriakidis, C. van de Weijer, B. van Arem, and R. Happee, "The deployment of advanced driver assistance systems in Europe," *SSRN Electronic Journal*, 2015. [Accessed by 12/02/2025].
14. M. Marciano, S. Díaz, J. Pérez, and E. Irigoyen, "A review of shared control for automated vehicles: Theory and applications," *IEEE Trans. Human-Mach. Syst.*, vol. 50, no. 6, pp. 475–491, 2020.
15. M. Bojarski, D. D. Testa, D. Dworakowski, B. Firner, B. Flepp, P. Goyal, L. D. Jackel, M. Monfort, U. Muller, J. Zhang, X. Zhang, J. Zhao, and K. Zieba, "End to end learning for self-driving cars," *arXiv:1604.07316*, 2016. [Accessed by 15/02/2025].
16. N. M. Enache, S. Mammam, M. Netto, and B. Lusetti, "Driver steering assistance for lane-departure avoidance based on hybrid automata and composite Lyapunov function," *IEEE Transactions on Intelligent Transportation Systems*, vol. 11, no. 1, pp. 28–39, 2010.
17. P. A. Hancock, D. R. Billings, K. E. Schaefer, J. Y. C. Chen, E. J. de Visser, and R. Parasuraman, "A meta-analysis of factors affecting trust in human-robot interaction," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 53, no. 5, pp. 517–527, 2011.

Publisher's Note: The publisher remains impartial concerning jurisdictional claims in published maps and institutional affiliations. Responsibility for the content rests entirely with the authors and does not necessarily reflect the publisher's perspectives.